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DOE/PC/89807--T1

DE91 005596

AN EVALUATION OF A PRE-CHARGING PULSE-JET FILTER FOR SMALL COMBUSTOR PARTICULATE CONTROL

DOE CONTRACT NO. DE-AC22-89PC89807

PROJECT QUARTERLY REPORT

NOVEMBER 1990

FOR THE PERIOD OF JUNE - AUGUST 1990

PREPARED BY

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NOV 2 1 1990

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1.0 INTRODUCTION

A current national initiative is the replacement of natural gas and petroleum derived fuels with coal. In response to this initiative, the Department of Energy and private industry are developing a group of small to medium scale coal fired combustors over a size range from residential to light industrial. The success of this program depends on the availability of air pollution control systems suitable for use on the combustors and capable of satisfying control regulations anticipated for the 1990's.

Historically, combustors in this size range, even when coal fired, have had only rudimentary pollution controls, or none at all. On the other hand, particulate control by an electrostatic precipitator has been the norm for large coal fired utility boilers for many years. There are several reasons for this size dependent regulatory structure. The principal reason is that the large coal fired combustors generate the majority of particulate. Another reason is that the typical small combustor owner does not have the resources to operate and maintain a pollution control device such as an electrostatic precipitator.

If the use of coal in small scale combustors is successfully encouraged, then suitable pollution control devices must be an integral part of the combustor's system in order to prevent deterioration of air quality resulting from increased coal combustion. The operation and maintenance of these devices must be tolerated by the individuals and small companies which will utilize the combustors. Such control devices need to be developed in parallel with the development of the small-scale combustors.

Considering the array of commercially available particulate control devices, the pulse-jet fabric filter most closely meets these specifications. It is among the smallest of particulate control devices per unit gas flow, and it is one of the most commonly utilized particulate control device for small (less than 10,000 CFM) applications. The pulse-jet fabric filter has no moving parts and yields a dry ash product which can be disposed with combustor bottom ash. Pulse-jet filters are often applied to processes in which severe load swings are commonplace, with frequent stops and starts.

The desired emission level for particulate of .02 lb/10^6 Btu represents a collection efficiency of approximately 98% when burning Beneficiated Illinois #6 Coal. Fabric filtration is generally recognized as being capable of achieving the highest collection efficiency of any particulate control technology. Overall collection efficiency of 99.9% is commonly guaranteed by vendors. Recently it has been found that the good collection efficiency of the fabric filter can be substantially improved by means of charging the particles prior to filtration. Typically, this technique has been shown to increase collection efficiency from 99.9% to 99.99%, or a ten-fold reduction in emissions. It has also been found that lower pressure drop across the filter results when charged particles are filtered. This additional performance enhancement can result in lowered operating costs or can allow the designer to reduce the size of the filter.

Based upon results such as these, it is clear that a pulse-jet fabric filter, equipped with a particle charger, can provide superior particulate control for the small combustor application, as well as meet all the requirements of simplicity, compactness, and reliability.

2.0 OBJECTIVE

The objective of this test program is the performance and economic evaluation of a pre charged-pulse jet filter as the principal particulate control device for a commercial or industrial scale coal fired combustor. Performance factors that will be considered are the effects of particle charge, air/cloth ratio, fabric types, percent humidity and inlet particulate loading on fine particle collection efficiency, and pressure drop. Economic factors that will be considered are capital costs, energy and other operating costs, and maintenance costs.

The program will result in a recommendation regarding the relative suitability of the pre charged pulse-jet filter for small combustor particulate control, as compared to other control devices. Fine particle control capability, ease of operation, and overall economics will be taken into consideration in making comparisons.

3.0 PROGRAM PLAN

This research project is divided into six distinct functional categories, or tasks, which must be completed in sequence. These tasks are categorized as follows:

- TASK 1: Work Plan
- TASK 2: Design, Procurement, and Installation
- TASK 3: Shakedown
- TASK 4: Test Program
- TASK 5: Analysis and Economic Evaluation
- TASK 6: Reporting

A schedule for the completion of Tasks 1 through 6 is provided in Table I, Milestone Schedule, where shaded portions of the graphic represent the monthly status of work performed. Table II, Cost Management Report, represents the status of accrued costs and Estimated Accrued Costs up to September 1, 1990. Table III includes a monthly status of Labor Hours, Costs expended, and Milestones.

4.0 WORK PERFORMED

4.1 Installation and shakedown of the test system and measurement devices continued. Completed installation tasks included the following:

a) Ash feed system was perfected to deliver a fly ash into the baghouse with a particle diameter distribution of 95% less than 20 μm (Appendix A).

b) A charge measurement sampling device was fabricated to yield reproducible results. Data is contained in Appendix B as well as a schematic diagram of the measurement device.

c) A vibrator was installed on the bottom of the ground plate to dislodge excess ash that gets trapped between the 1" square grids. A heavy ash accumulation increases the potential required to get a uniform corona discharge.

d) Ryton and Tefaire fabric filter were installed.

4.2 The test program started on July 31 and was canceled on August 10, 1990 because the charge measurement device was yielding inconsistent results. It was determined that thermal equilibrium, component stress relief, and ground the metal probe were necessary for reproducible operation.

4.3 Impactor data collected prior to August 30 was of limited quality because sample collection was over isokinetic. Retraining of the newly hired temporary technicians solved the problem.

4.4 Improvements were made to the pulsed energization system circuitry that yielded energization levels of 40 KV at 300 ppm for eastern fly ash in the concentration range of 0.2-3 g/dscf at 300°F. The pulse potential was superimposed on a base potential of 20 KV, D C (negative).

4.5 The test program was restarted on August 28. Data is included in Appendix C.

5.0 WORK TO BE COMPLETED NEXT QUARTER

Complete test program.

6.0 STATUS SUMMARY

Test system shakedown has been completed. Sampling and Analysis of the test plan has started and is expected to be completed in September. Temporary employee labor has put us above the man hours expected in the labor plan but we are within budget because we do not have an overhead cost for temporary labor. The testing program is run 24 hours a day for 5 days a week.

Jay M. Quimby
Project Manager

Contract DE-AC22-89PC89807

Key Personnel Labor Report

For The Period June-August 1990

Person	June (hours)	July (hours)	August (hours)	Total (hours)
D.J.Helfritch	36	31	84	151
J.M.Quimby	106	106	124	336

TITLE	FPE CHARGING PULSE JET FILTER
PARTICIPANT	RESEARCH-COTTRELL, EST, PO BOX 1500, SOMERVILLE, NJ 08876
CUST PLAN DATE	10-25-89
REPORT PERIOD	AUGUST 1990
IDENTIFIC	DE-AC22-89PC89807
START DATE	10/01/1989
COMPLETION DATE	11/30/1990

REPORT ELEMENT	10. ACCRUED COSTS This Report a.actual	b.plan	Cumulative c.actual	d. plan	11. ESTIMATED ACCRUED COSTS a. next period	b. FY90 balance	c. FY 1991	e.total	12 TOTAL CONT. VALUE	TOTAL VAR.
MATERIAL	1.5	0	14.0	41	0	0	0	14.0	41	27.0
DIRECT L	16.9	6	87.2	103	6	1	12	106.2	122	15.8
OVERHEAD	8.3	6	75.0	84	6	0	10	90.5	100	9.5
TRAVEL	0.1	0	1.2	1	1	0	1	3.2	3	-0.2
NON-EXPEN	0.6	0	1.0	0	0	0	0	1.0	0	-1.0
SUBTOTAL	27.4	12	178.4	230	13	1	23	213.9	266	52.1
G&A	4.3	2	27.8	30	2	0	3	27.8	34	6.5
SUBTOTAL	31.7	13	206.2	259	15	1	26	241.7	300	58.6
FEE	2.5	1	16.5	21	1	0	2	19.3	24	4.7
TOTAL	34.2	14	222.7	280	16	1	28	261.0	324	63.3

DOLLARS EXPRESSED IN: THOUSANDS

SIGNATURE AND DATE OF PROJECT MANAGER

9-21-90

SIGNATURE AND DATE OF AUTHORIZED FINANCIAL REPRESENTATIVE

DE F 1332.3
(1-84)

U.S. DEPARTMENT OF ENERGY

MILESTONE SCHEDULE ☐ PLAN ☐ STATUS REPORT

FORM APPROVED
OMB NO. 1901-1400

TITLE Pre Charging Pulse Jet Filter for Small Combustor Particulate Control	2. REPORTING PERIOD 0/01/90 – 8/31/90	3. IDENTIFICATION NUMBER DE-AC22-89PC89807
PARTICIPANT NAME AND ADDRESS Research-Cottrell Environmental Services And Technologies P.O. Box 1500 Somerville, New Jersey 08876		5. START DATE 10/1/89
		6. COMPLETION DATE 11/30/90

TASK	9. DURATION FY 1990												FY 1991										FY	FY	10. PERCENT COMPLETE	
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J			a. Plan	b. Actual
ORK PLAN																									100	100
ESIGN, PROCURE, INSTALL																										
HAKEDOWN																										
ESTING																										
NALYSIS & CONOMICS																										
EPORT																										

SIGNATURE OF PARTICIPANT'S PROJECT MANAGER AND DATE

DOE F1332.2
(11-84)

U.S. DEPARTMENT OF ENERGY
SUMMARY REPORT

FORM APPROVED
OMB NO. 1901-1400

1. IDENTIFICATION NUMBER	2. PROGRAM/PROJECT TITLE	3. REPORTING PERIOD
DE-AC22-89PC89807	Charged Filter	Quarter Ending August

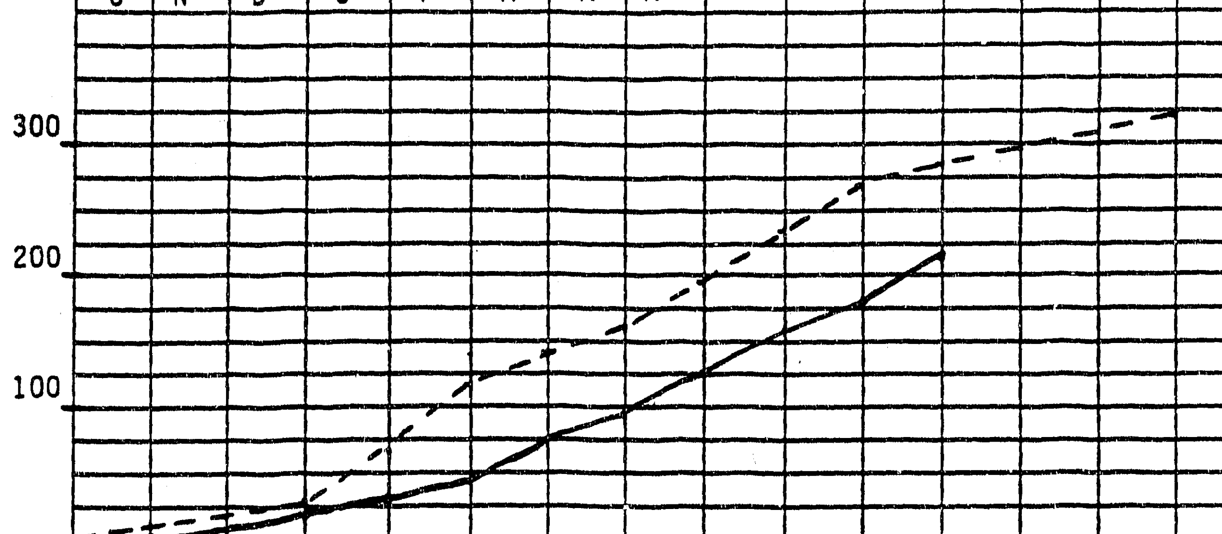
4. PARTICIPANT NAME AND ADDRESS
R-C Environmental Services & Tech
P.O. Box 1500
Somerville, N.J. 08876

5. START DATE: 10/1/89

6. COMPLETION DATE 11/30/90

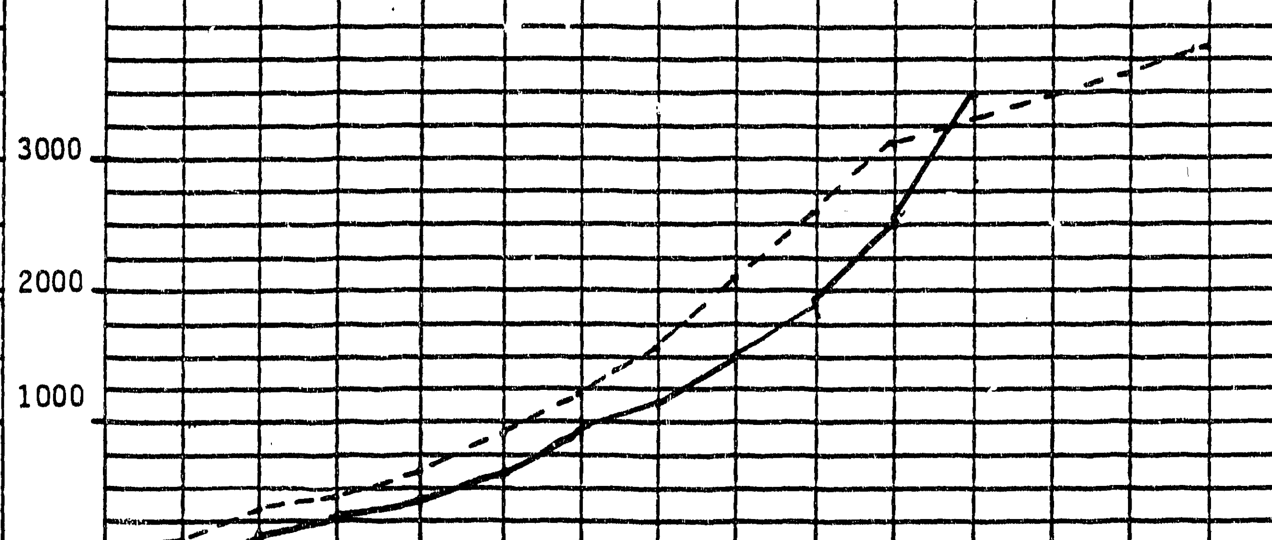
7. FY 90 | 8. MONTHS

9. COST STATUS
a. $ Expressed in: Thousands
b. Budget and Reporting No.
c. Cost Plan Date 10/25/89
d. Actual Costs Prior Years -
e. Planned Costs Prior Years -
f. Total Estimated Cost for Contract 324
g. Total Contract Value 324
h. Estimated Subsequent Reporting Period



Accrued Costs	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
g. Planned	8	11	7	42	48	22	22	35	37	38	13	13	13	15	
h. Actual	3	7	10	13	15	24	20.7	35	33	25	37				
i. Variance	5	4	(3)	29	13	(2)	1.3	0	4	13	(24)				
j. Cumulative Variance	5	9	6	35	68	66	67	67	71	84	60				

10. LABOR STATUS
a. Labor Expressed in: Hours
b. Labor Plan Date: 10/31/89
c. Planned Labor Prior Fiscal Years -
d. Actual Labor Prior Fiscal Years -
e. Total Estimated Labor for Contract 3860
f. Total Contract Labor 3860

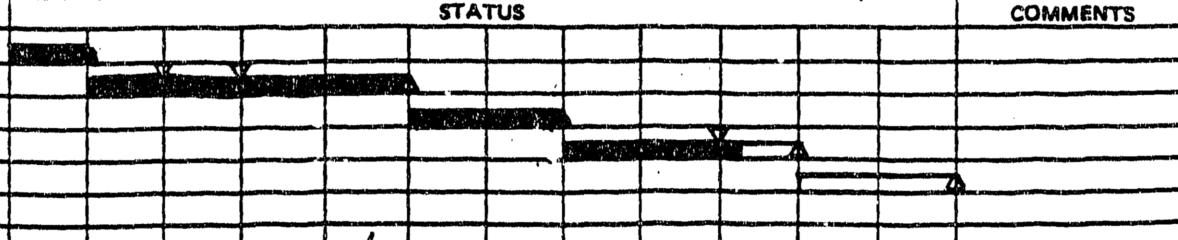


LEGEND
Planned: - - - - - -
Actual: ———————
Projected: . . . .

Labor	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
g. Planned	100	190	100	270	270	300	310	520	520	520	190	190	190	190	
h. Actual	50	108	134	168	212	315	197	40[illegible]	400	517	1008				
i. Variance	50	82	(34)	102	58	(15)	113	114	120	3	(818)				
j. Cumulative Variance	50	132	98	200	258	243	356	470	590	593	(225)				

11. MILESTONES | STATUS | COMMENTS

a. Work Plan
b. Design, Install
c. Shakedown
d. Testing
e. Analysis
f. Report



12. SIGNATURE OF PARTICIPANT'S PROJECT MANAGER AND DATE

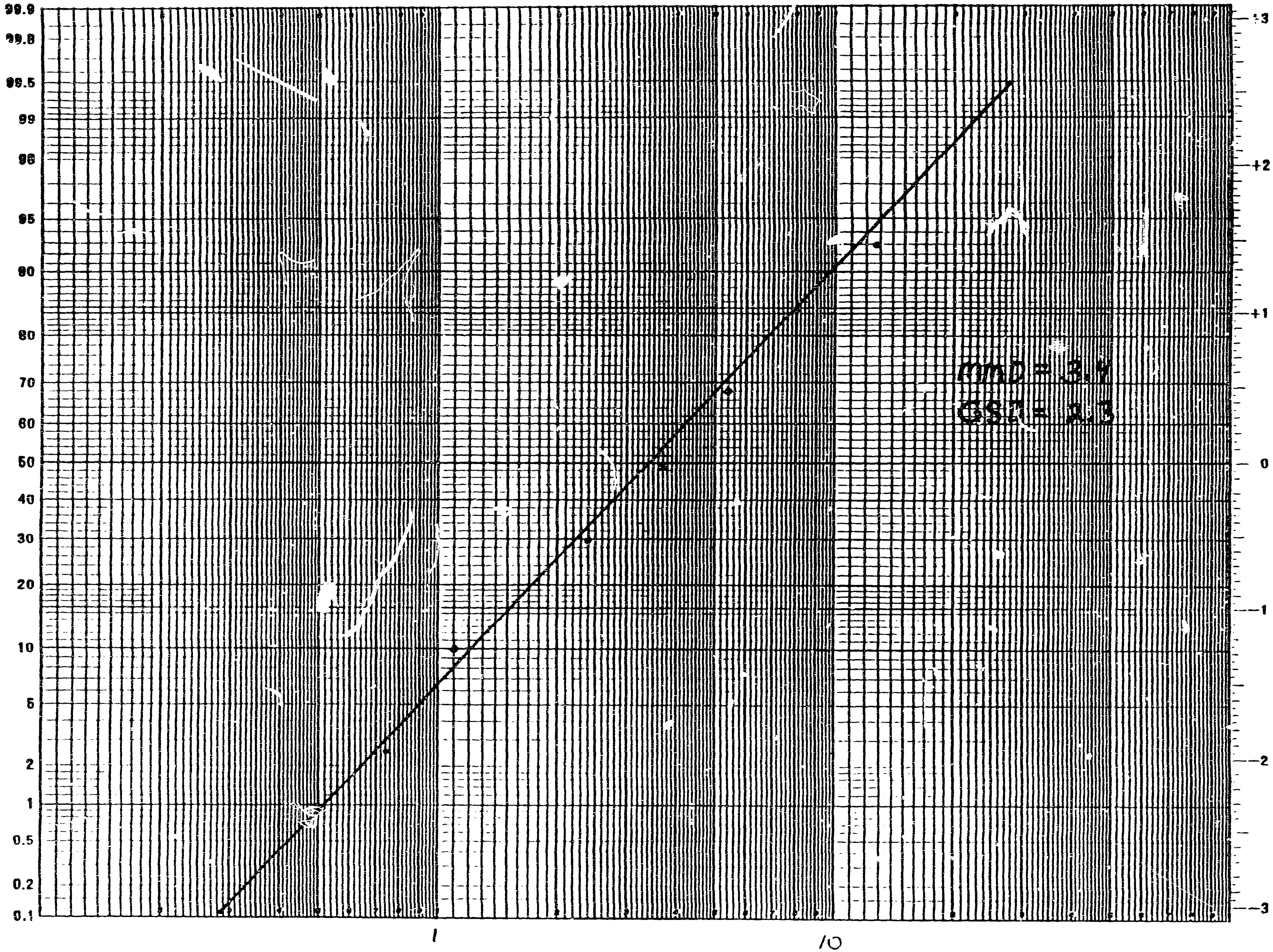
APPENDIX A

Data on Ash Size (mass median diameter) obtained from an Andersen Mark III Cascade Impactor sampling the gas stream at the inlet of the baghouse. Dispersed ash is blown into the heated gas stream from the exit of a gravitational preseparator. The preseparator removes large particles and agglomerates from an aspirator that conveys the ash, dropped in the aspirator hopper, from a screw feeder.

Cascade Impactor Data of Mercer Station Fly Ash After Preseparator
Run #1, June 1, 1990

Impactor stage	Tare (g)	Final (g)	Net (g)	% in Size Range	%Cumulative Less Than Size Range	Effective Cut Diameter
0	20.7106	20.7164	0.0058	7.125	92.875	12.8
1	21.9565	21.9630	0.0065	7.985	84.889	8.0
2	22.6614	22.6755	0.0141	17.322	67.568	5.4
3	15.2280	15.2428	0.0148	18.182	49.386	3.7
4	11.1842	11.2003	0.0161	19.779	29.607	2.4
5	11.1705	11.1863	0.0158	19.410	10.197	1.1
6	11.1107	11.1170	0.0063	7.740	2.457	0.74
7	21.8817	21.8829	0.0012	1.474	0.983	0.50
Filter	1.5789	1.5797	0.0008	0.983	0.000	0.3
			0.0814			

Flvash analysis by cascade Impactor After Preseparator Run #1

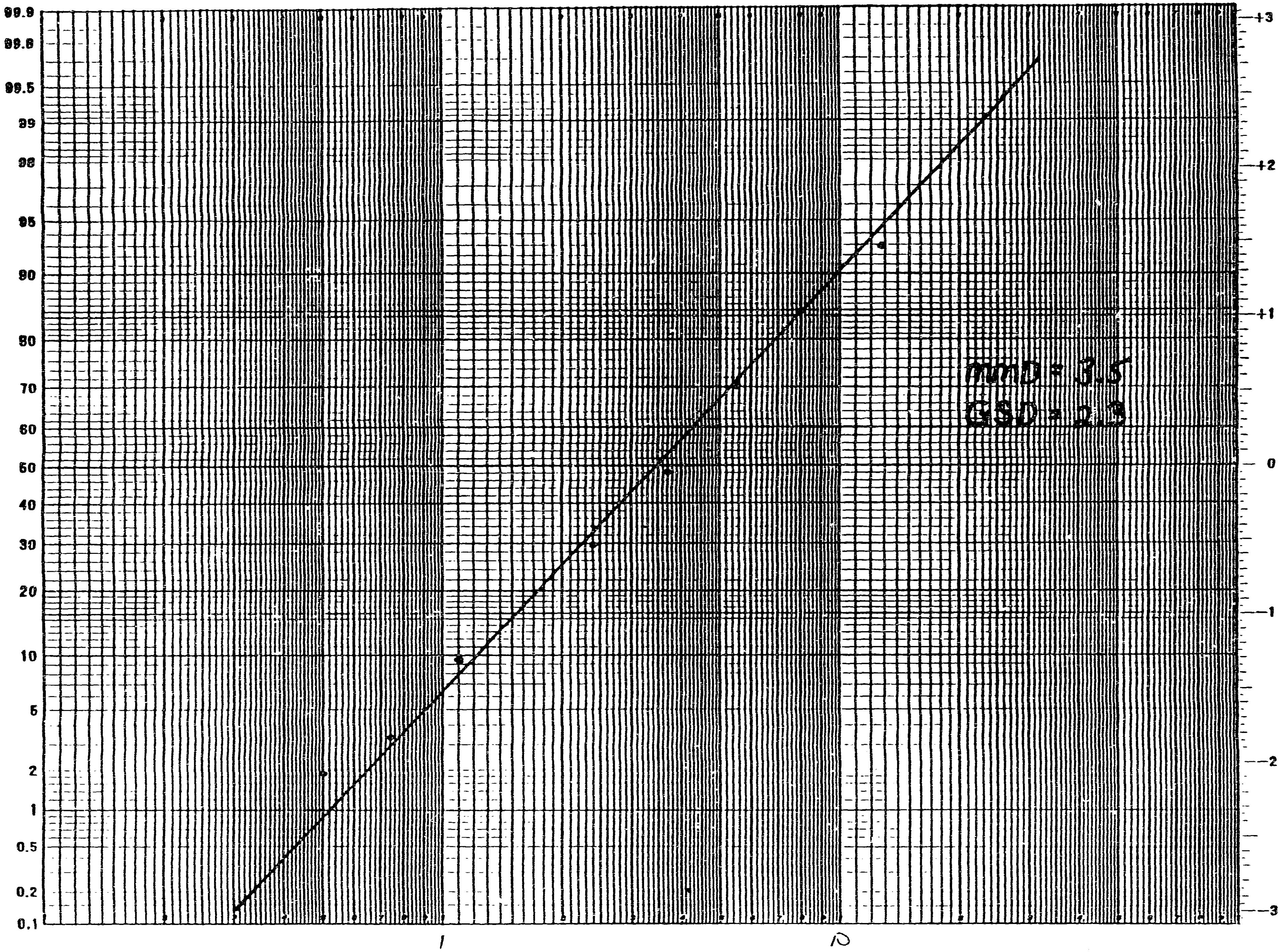


Cascade Impactor Data of Mercer Station Fly Ash After Preseparator
Run #2, June 1, 1990

Impactor stage	Tare (g)	Final (g)	Net (g)	% in Size Range	%Cumulative Less Than Size Range	Effective Cut Diameter
0			0.0058	7.099	92.901	12.8
1			0.0063	7.711	85.190	8.0
2			0.0121	14.810	70.379	5.5
3			0.0171	20.930	49.449	3.7
4			0.0162	19.829	29.621	2.4
5			0.0163	19.951	9.670	1.1
6			0.0051	6.242	3.427	0.74
7			0.0012	1.469	1.958	0.50
Filter			0.0016	1.958	-0.000	0.3
			0.0817			

.52 grains/ per cf

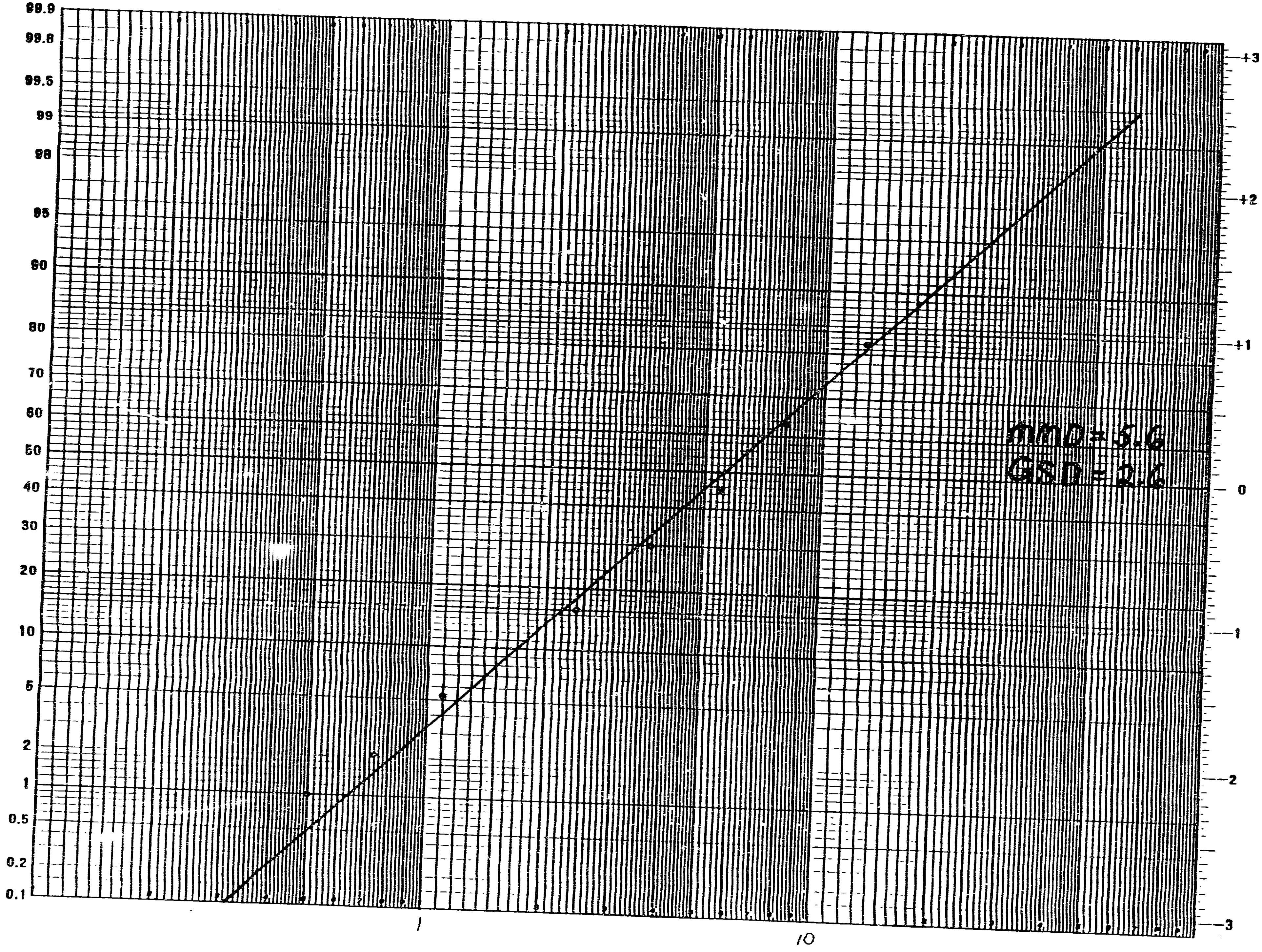
Flyash analysis by Cascade Impactor After Preseparator Run #2



Cascade Impactor Data of Mercer Station Fly Ash Without Preseparator
Run #3, June 6, 1990

Impactor stage	Tare (g)	Final (g)	Net (g)	% in Size Range	%Cumulative Less Than Size Range	Effective Cut Diameter
0			0.0166	17.792	82.208	12.8
1			0.0174	18.650	63.558	8.0
2			0.0169	18.114	45.445	5.5
3			0.0145	15.541	29.904	3.7
4			0.0126	13.505	16.399	2.4
5			0.0104	11.147	5.252	1.1
6			0.0029	3.108	2.144	0.74
7			0.0011	1.179	0.965	0.50
Filter			0.0009	0.965	0.000	0.3
			0.0933			

Preseparator Run#3

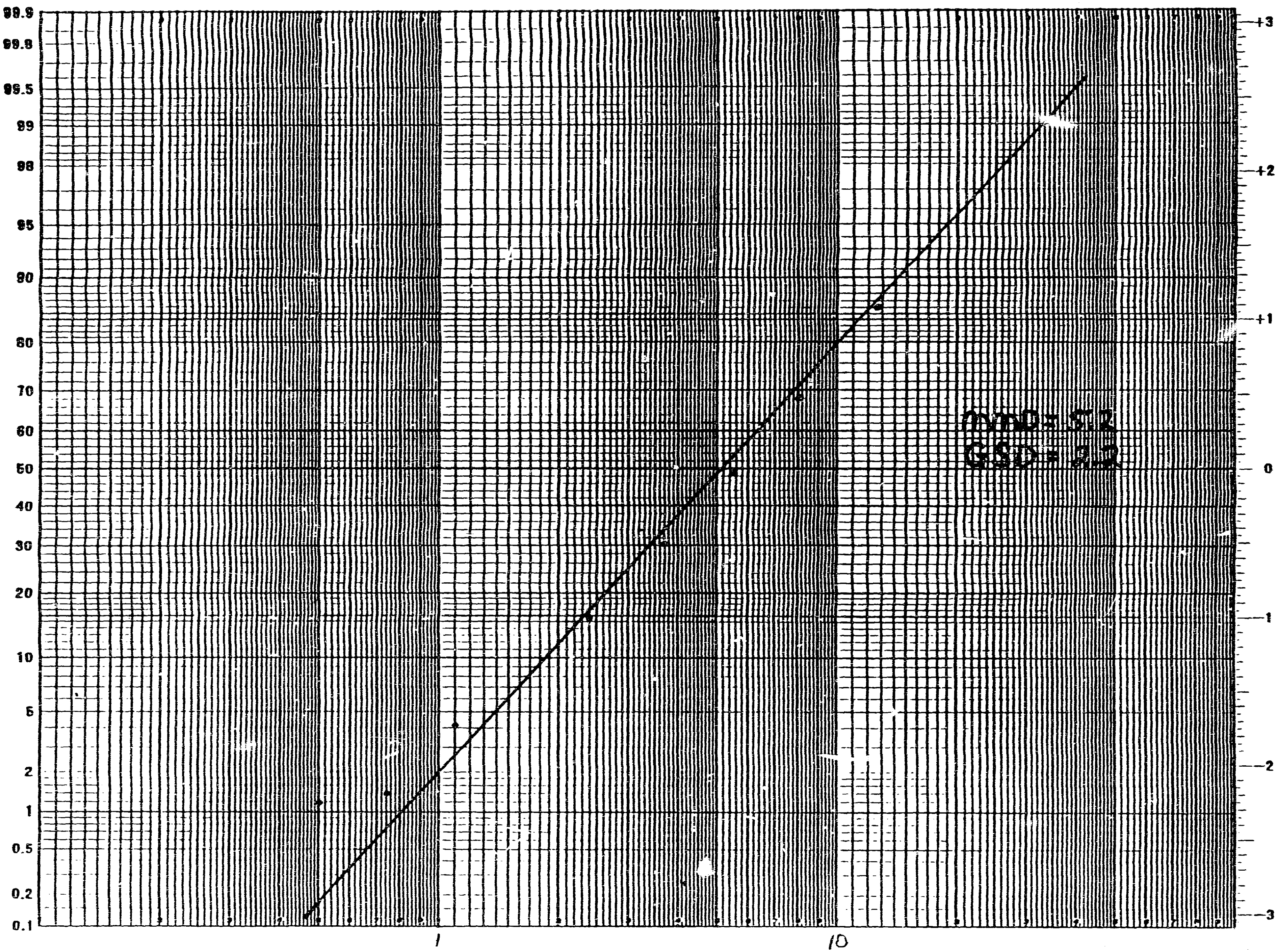


Cascade Impactor Data of Mercer Station Fly Ash After Preseparator
Run #4, June 6, 1990

Impactor stage	Tare (g)	Final (g)	Net (g)	% in Size Range	%Cumulative Less Than Size Range	Effective Cut Diameter
0			0.0109	14.248	85.752	12.8
1			0.0136	17.778	67.974	8.0
2			0.0146	19.085	48.889	5.5
3			0.0140	18.301	30.588	3.7
4			0.0114	14.902	15.686	2.4
5			0.0088	11.503	4.183	1.1
6			0.0021	2.745	1.438	0.74
7			0.0002	0.261	1.176	0.50
Filter			0.0009	1.176	0.000	0.3
			0.0765			

.52 grains/(per cf

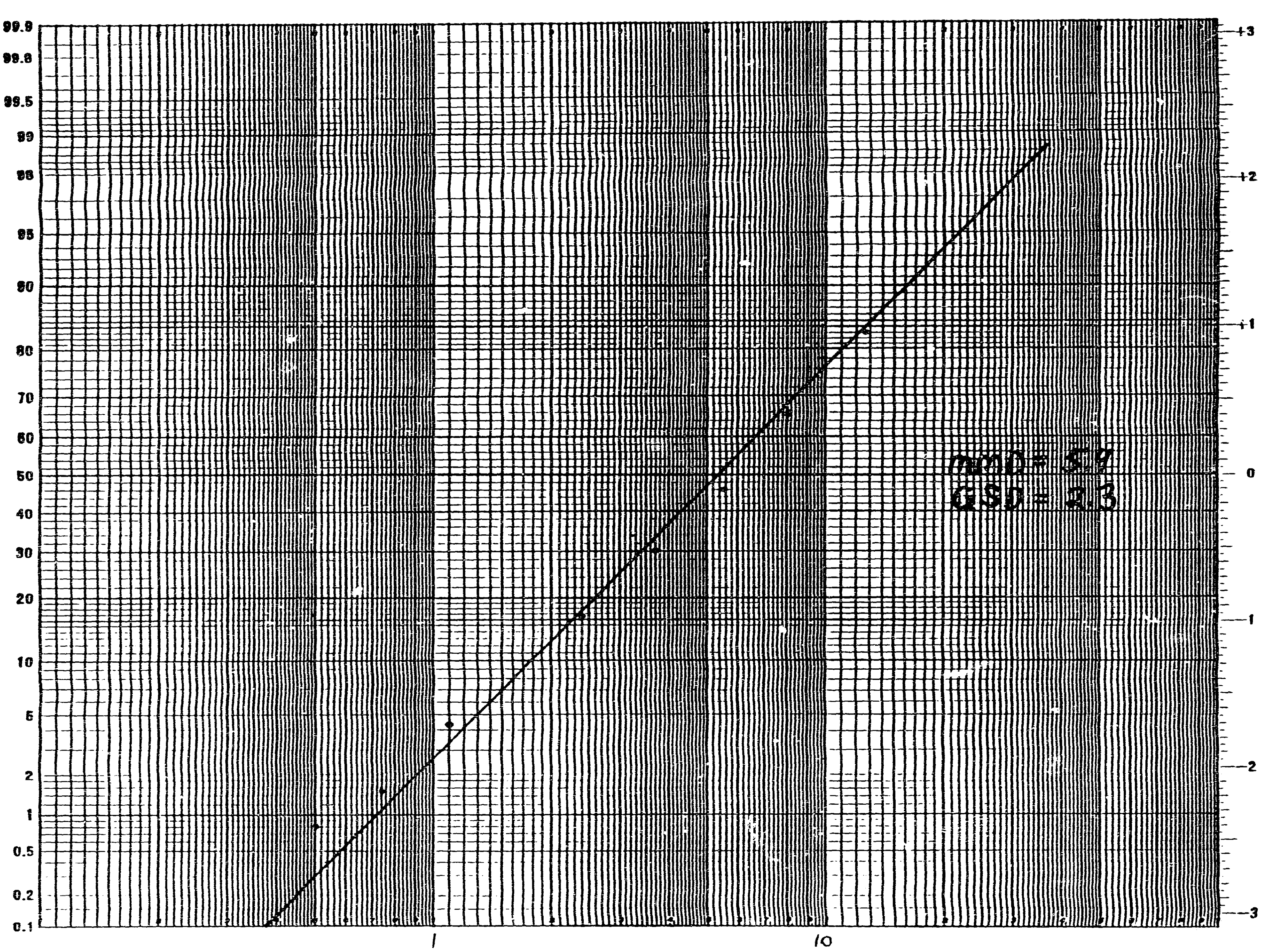
Flyash Analysis by Cascacade Impactor After Preseparator Run #4



Cascade Impactor Data of Mercer Station Fly Ash After Preseparator
Run #5, June 8, 1990

Impactor stage	Tare (g)	Final (g)	Net (g)	% in Size Range	%Cumulative Less Than Size Range	Effective Cut Diameter
0			0.0147	16.955	83.045	12.8
1			0.0149	17.186	65.859	8.0
2			0.0168	19.377	46.482	5.5
3			0.0140	16.148	30.334	3.7
4			0.0120	13.841	16.494	2.4
5			0.0105	12.111	4.383	1.1
6			0.0025	2.884	1.499	0.74
7			0.0006	0.692	0.807	0.50
Filter			0.0007	0.807	0.000	0.3
			0.0867			

Flyash Analysis by Cascade Impactor After Preseparator Run #5

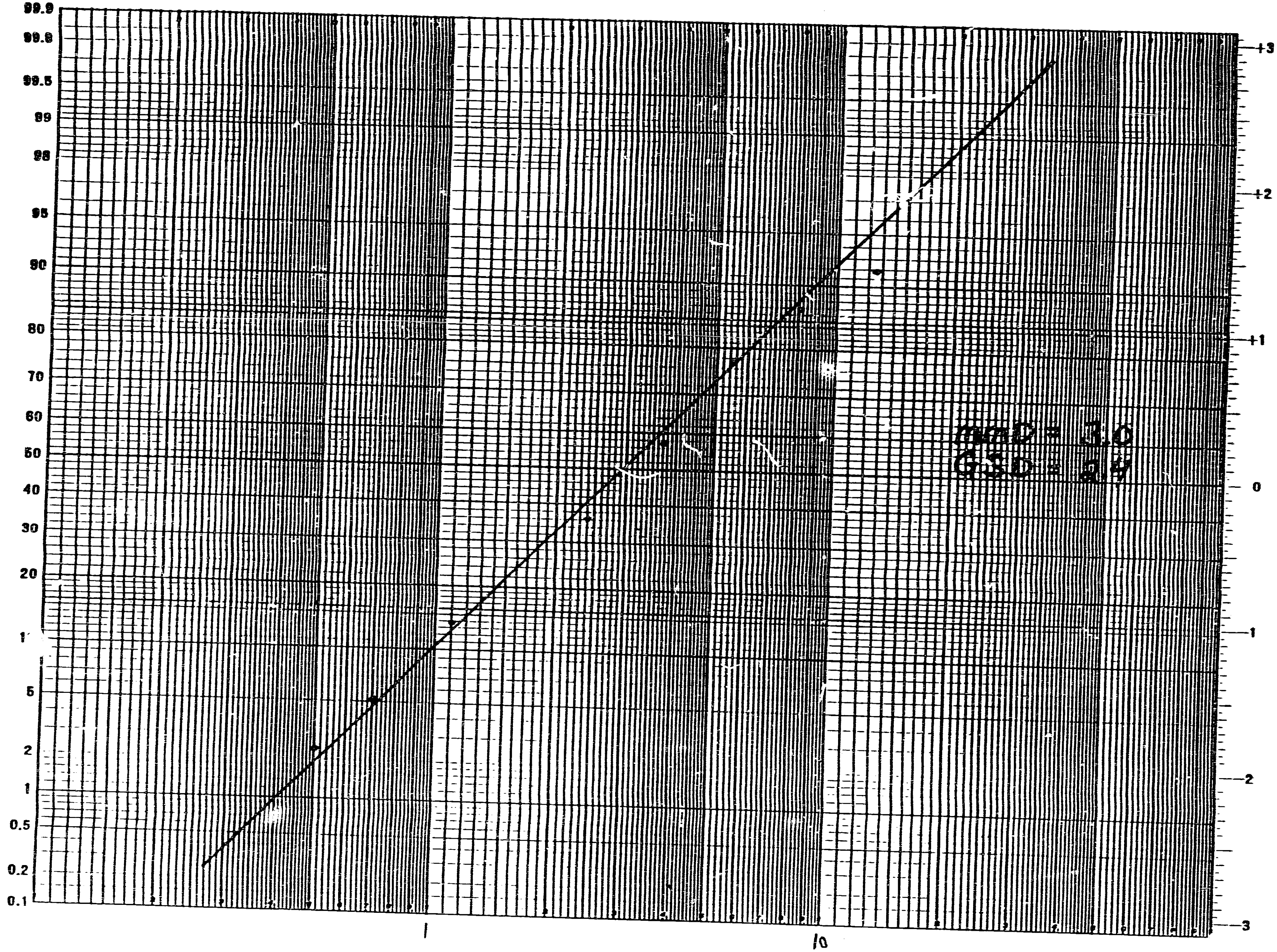


Cascade Impactor Data of Mercer Station Fly Ash After Preseparator
Run #6, June 15, 1990 Flow to Preseparator was reduced to 3.5 CFM

Impactor stage	Tare (g)	Final (g)	Net (g)	% in Size Range	%Cumulative Less Than Size Range	Effective Cut Diameter
1			0.0029	8.357	91.643	12.8
2			0.0017	4.899	86.744	8.0
3			0.0032	9.222	77.522	5.5
4			0.0069	19.885	57.637	3.7
5			0.0073	21.037	36.599	2.4
6			0.0079	22.767	13.833	1.1
7			0.0030	8.646	5.187	0.74
8			0.0010	2.882	2.305	0.50
Filter			0.0008	2.305	0.000	0.3
			0.0347			

0.21 grains/cubic foot

Flyash Analysis by Cascade Impactor After Preseparator Run #6



APPENDIX B
CHARGE MEASUREMENT DEVICE DATA

Table 1. Data Collected Using the Charge Measurement Device

Date	Charge/Mass μC/g	Charge/Vol. μC/M^3	Charging Conditions	Notes
July 31	22.0	13.9	1/2 Max	Pulser not operational since July 27.
31	1.1	1.4	Zero	
August 1	1.9	1.6	Zero	
3	8.9	5.3	1/2 Max	
6	6.8	4.1	1/2 Max	
7	3.2	1.0	1/2 Max	
8	3.0	1.3	Zero	
9	4.3	2.9	Zero	
10	20.0	8.5	Zero	Stopped test program and evaluated charge measurement device.
13	2.2	0.4	Zero	Isolated stress on electrometer connection to probe.
13	24.5	3.5	1/2 Max	
13	19.5	2.5	1/2 Max	

Max = Base potential 20 KV; Pulser gap 40 KV
1/2 Max = Base potential 18-20 KV
Zero = No voltage applied to charger

Table 1, Continued

Date	Charge/Mass $\mu C/g$	Charge/Vol. $\mu C/M^3$	Charging Conditions	Notes
14	0.0	0.2	Zero	No ash feed.
16	12.3	1.8	1/2 Max	Corona points manually cleaned.
16	4.0	0.3	Zero	
21	0.5	0.0	Zero	No ash feed.
21	2.8	0.6	Zero	
22	2.0	0.0	Zero	No ash feed.
22	25.6	4.8	Max	Fixed pulser with 8 resistors.
22	2.8	0.5	Zero	Ash feed on.
23	9.0	2.1	1/2 Max	Grounded probe which reduced background charge by a factor of 10X.
24	19.4	7.5	Max	Permanantly fixed electrometer wire to charge measurement device. Charge measurement device considered fixed at this time.
28	28.2	6.8	Max	Start of test program with valid data.
29	23.1	3.5	1/2 Max	

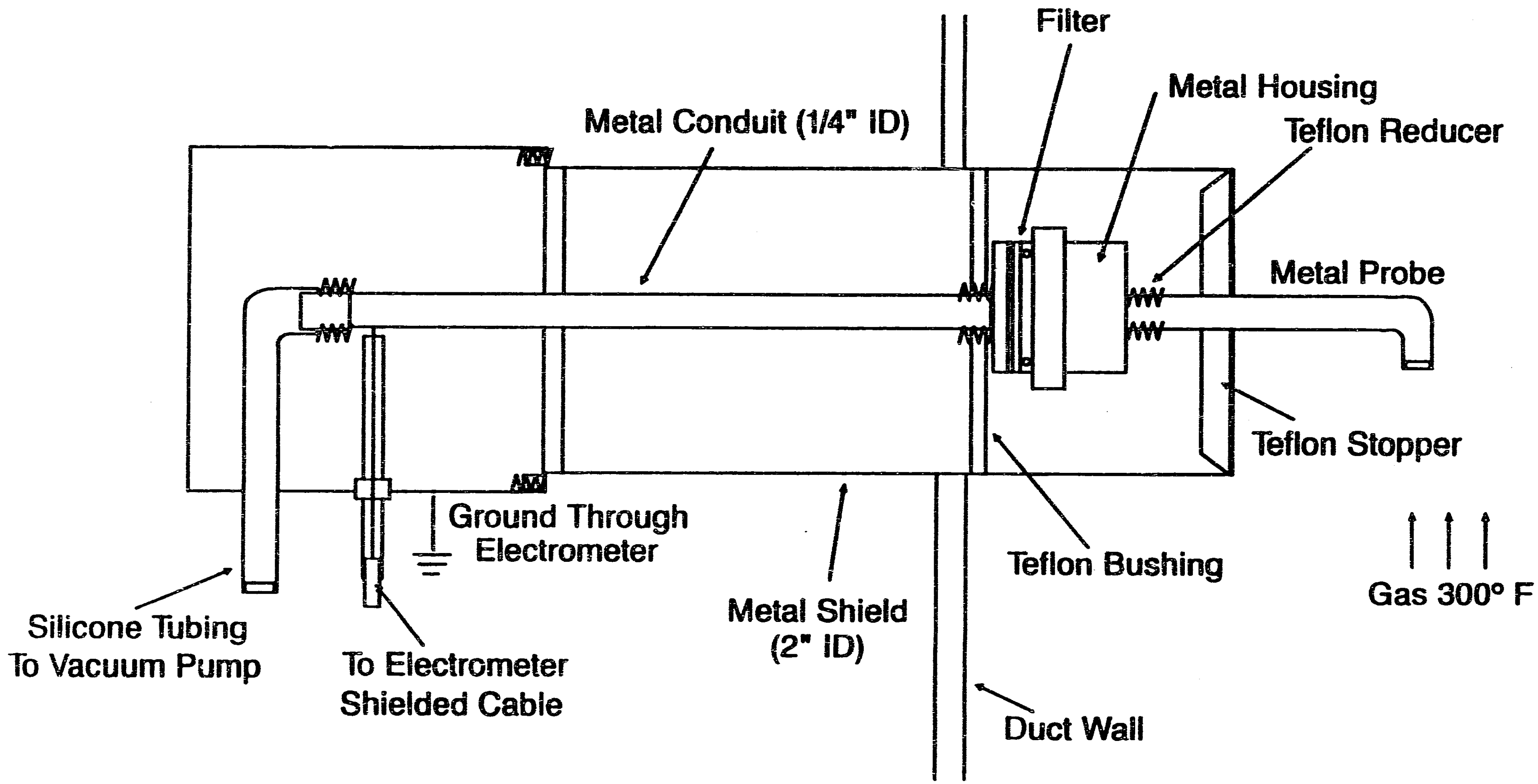
Max = Base potential 20 KV; Pulser gap 40 KV
1/2 Max = Base potential 18-20 KV
Zero = No voltage applied to charger

Table 1, Continued

Date	Charge/Mass µC/g	Charge/Vol. µC/M^3	Charging Conditions	Notes
30	0.6	0.1	Zero	
31	28.6	7.0	Max	

Max = Base potential 20 KV; Pulser gap 40 KV
1/2 Max = Base potential 18-20 KV
Zero = No voltage applied to charger

PARTICLE CHARGE MEASUREMENT DEVICE



APPENDIX C

VALID TEST DATA COLLECTED

FOR QUARTER

(JUNE-AUGUST)

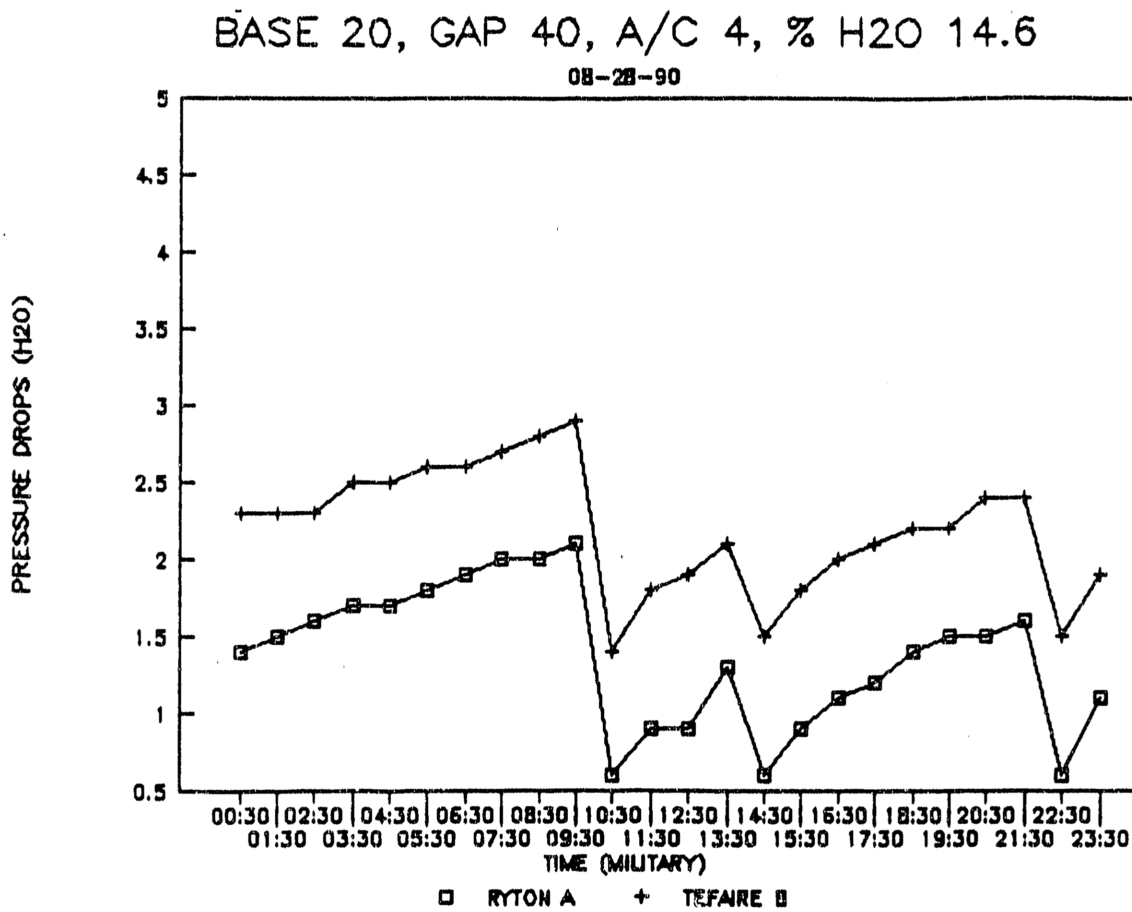


Figure 1. Pressure Drop Data Across Fabric Filters: Conditions and Dates are denoted above.

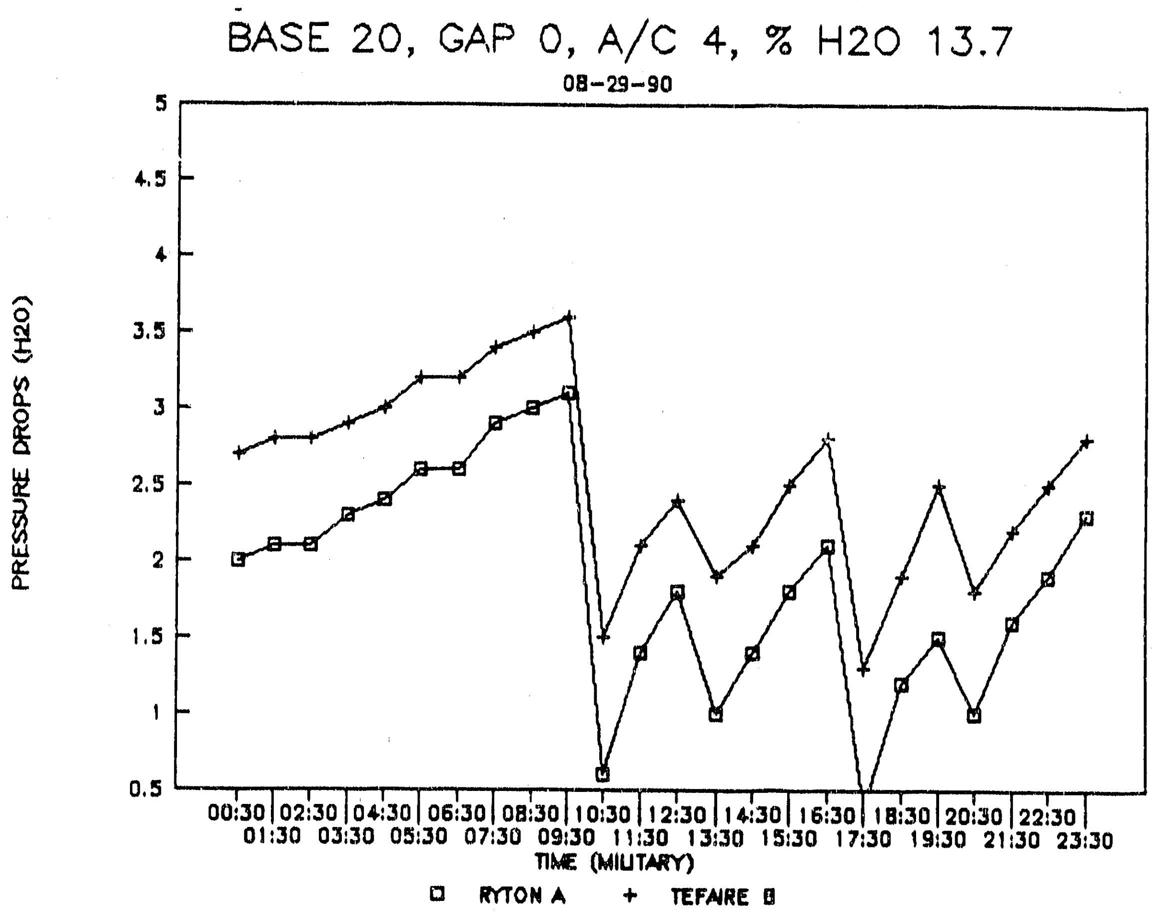


Figure 2. Pressure Drop Data Across Fabric Filters: Conditions and Dates are denoted above.

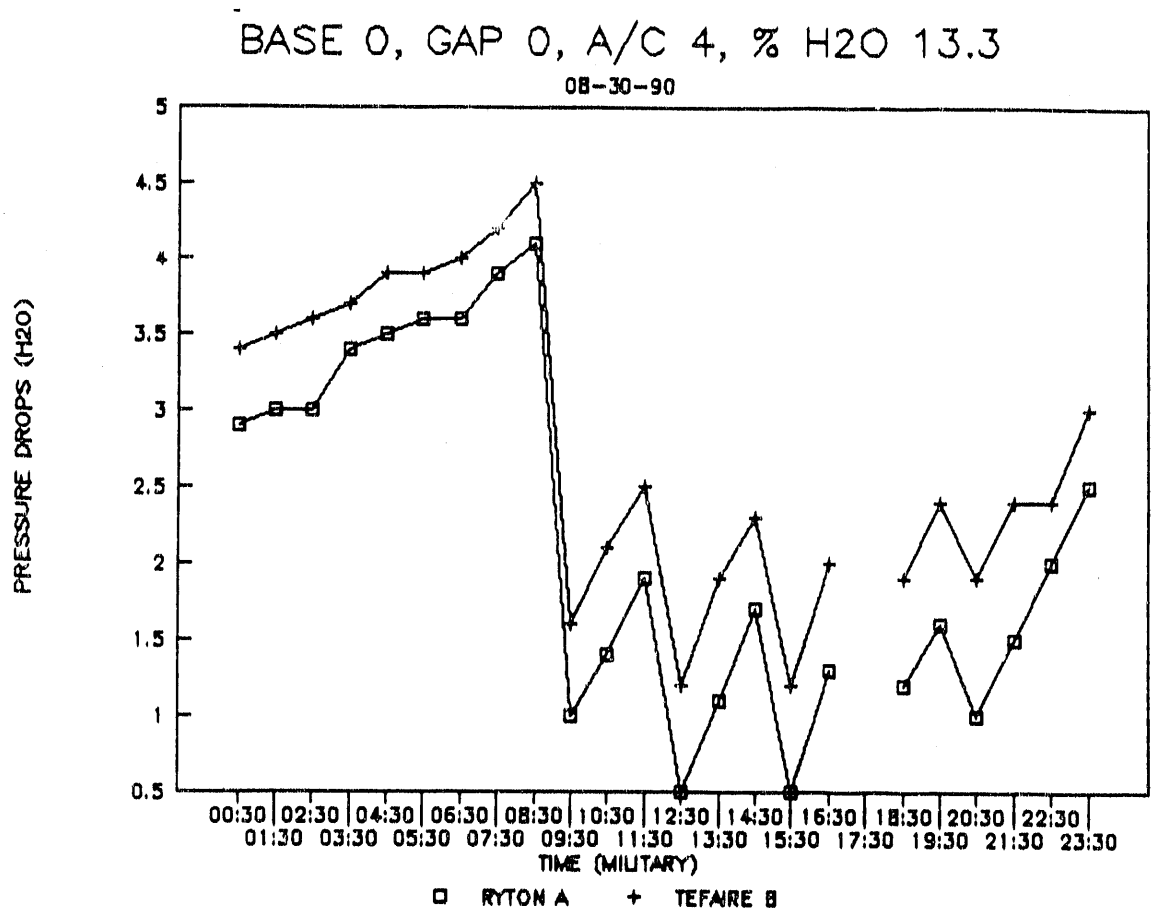


Figure 3. Pressure Drop Data Across Fabric Filters: Conditions and Dates are denoted above.

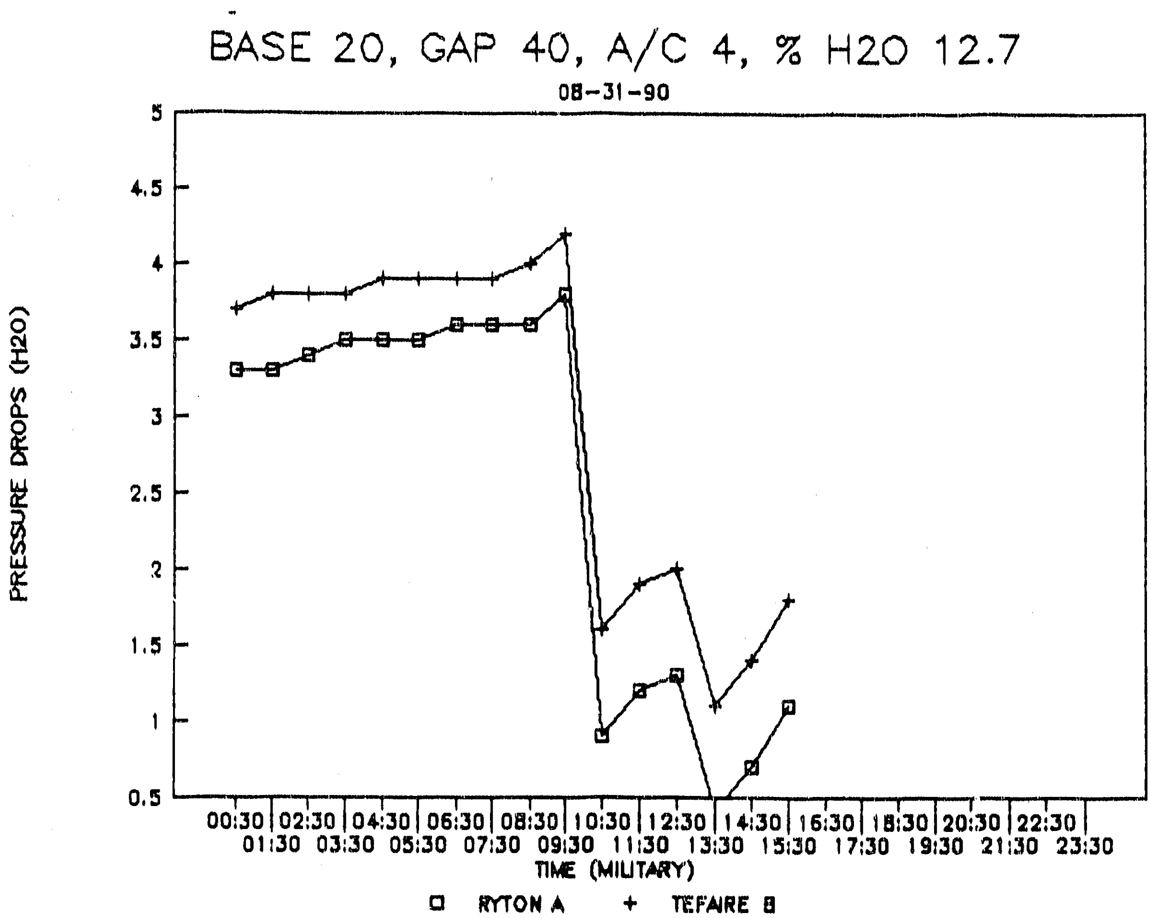


Figure 4. Pressure Drop Data Across Fabric Filters: Conditions and Dates are denoted above.

DE-AC22-89PC89807

Daily Summary

Date Aug. 28, 1990 Operator John Milojevac

Baghouse Inlet Temperature 320 °F

Orifice Flow Rate (Q_B) 190 Acfm (B) Tefaire

Orifice Flow Rate (Q_A) 195 Acfm (A) Ryton

Ash Type Eastern X Western ____

Corona Potential Base KV 20 Pulser KV 40

Pulse Rate 300 pps

Moisture Content 14.6 % (v/v)

Air to Cloth ratio ($Q/42.4\ ft^2$) Tefaire 4.48 ft/min

Ryton 4.60 ft/min

Average Pressure Drop Tefaire 2.25 " H_2O

Ryton 1.3 " H_2O

Particle Concentration

Inlet ____ grains/dscf Tefaire outlet ____ g/dscf Ryton outlet .0047 g/dscf

Particle Size Distribution

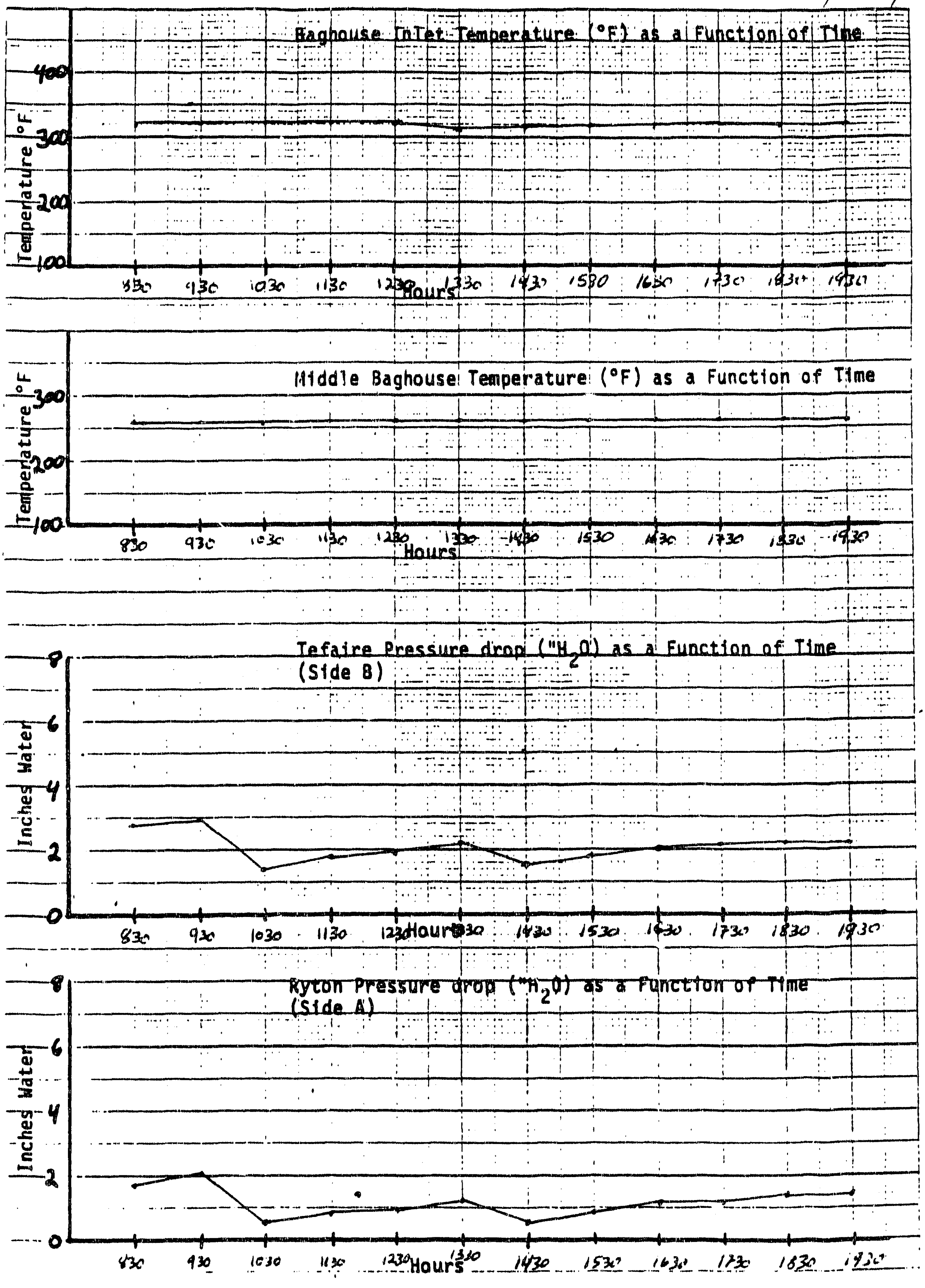
Inlet MMD ____ μm CMD ____ Tefaire outlet MMD ____ μm CMD ____ Ryton outlet MMD 4.4 μm CMD 2.73

Particle Charge

Charge to mass ratio (q/m) = 28.2 $\mu C/gram$

Charge to volume ratio (q/m^3) = 6.79 $\mu C/m^3$

Max 40+20 A/C = 4



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K-E 20 X 20 TO THE INCH KEUFFEL & ESSER CO.

DE-AC22-89PC89807

Daily Summary

Date Aug. 29, 1990 Operator John Milojevac

Baghouse Inlet Temperature 320 °F

Orifice Flow Rate (Q_B) 210 Acfm (B) Tefaire

Orifice Flow Rate (Q_A) 210 Acfm (A) Ryton

Ash Type Eastern X Western ______

Corona Potential Base KV 20 Pulser KV Off

Pulse Rate Off pps

Moisture Content 13.7 % (v/v)

Air to Cloth ratio ($Q/42.4\ ft^2$) Tefaire 4.95 ft/min

Ryton 4.95 ft/min

Average Pressure Drop Tefaire 2.416 " H_2O

Ryton 1.624 " H_2O

Particle Concentration

Inlet ______ grains/dscf Tefaire outlet --- g/dscf Ryton outlet --- g/dscf

Particle Size Distribution

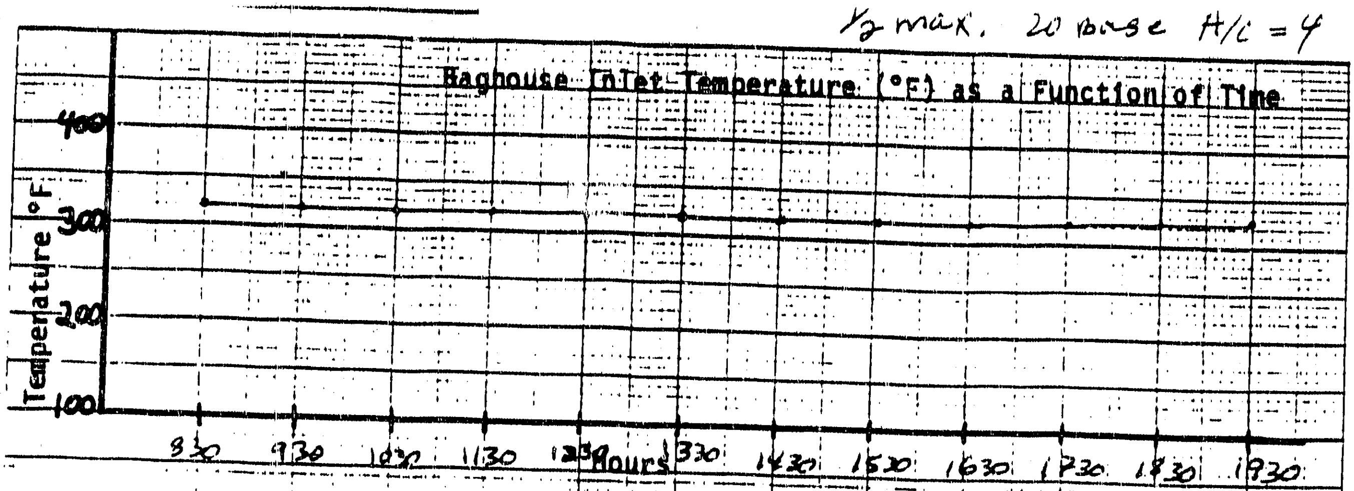
Inlet MMD ______ μm CMD ______ Tefaire outlet MMD ______ μm CMD ______ Ryton outlet MMD ______ μm CMD ______

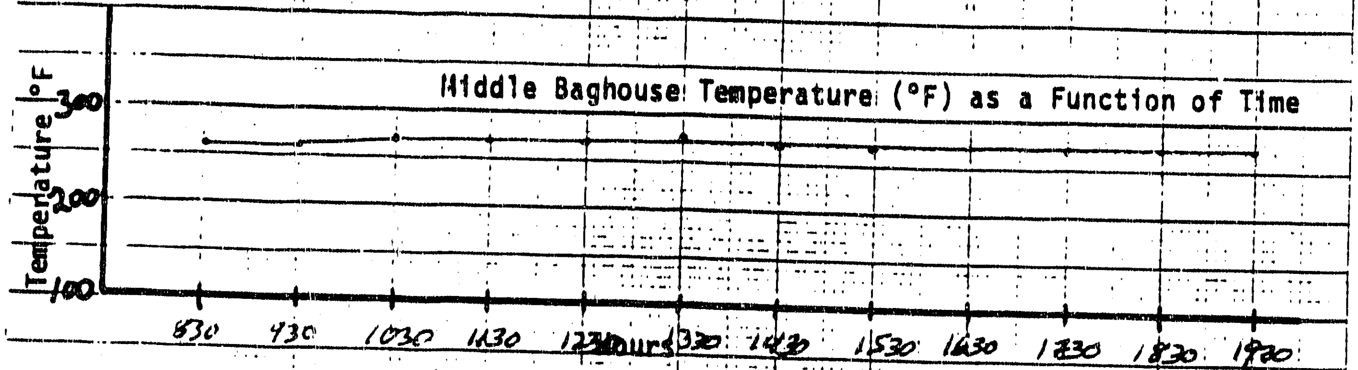
Particle Charge

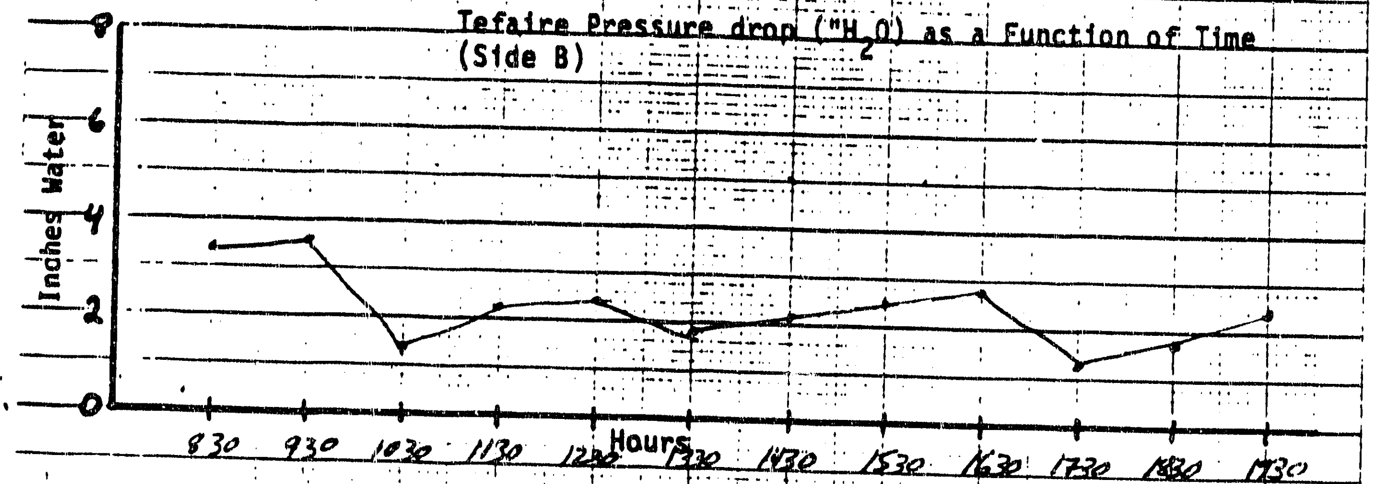
Charge to mass ratio (q/m) = 23.1 μC/gram

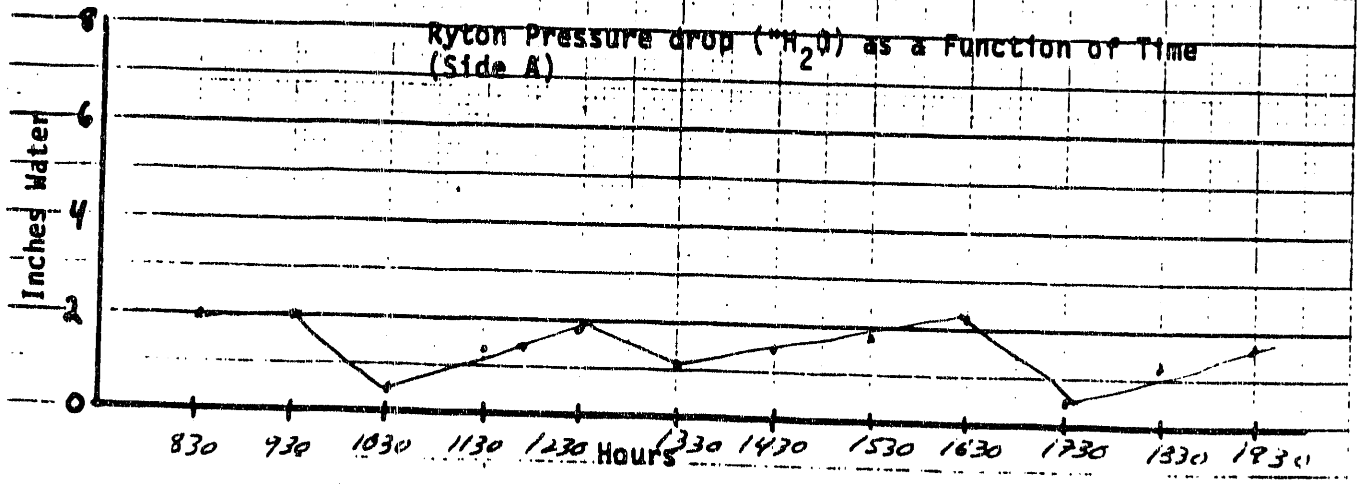
Charge to volume ratio (q/m^3) = 3.5 $\mu C/m^3$

½ max. 20 base A/C = 4









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DE-AC22-89PC89807

Daily Summary

Date Aug. 30, 1990 Operator John Milojevac

Baghouse Inlet Temperature 325 °F

Orifice Flow Rate (Q_B) 210 Acfm (B) Tefaire

Orifice Flow Rate (Q_A) 210 Acfm (A) Ryton

Ash Type Eastern X Western ____

Corona Potential Base KV Off Pulser KV Off

Pulse Rate Off pps

Moisture Content 13.3 % (v/v)

Air to Cloth ratio ($Q/42.4\ ft^2$) Tefaire 4.95 ft/min

Ryton 4.95 ft/min

Average Pressure Drop Tefaire 2.14 " H_2O

Ryton 1.50 " H_2O

Particle Concentration

Inlet ____ grains/dscf Tefaire outlet 0.0071 g/dscf Ryton outlet 0.0042 g/dscf

Particle Size Distribution

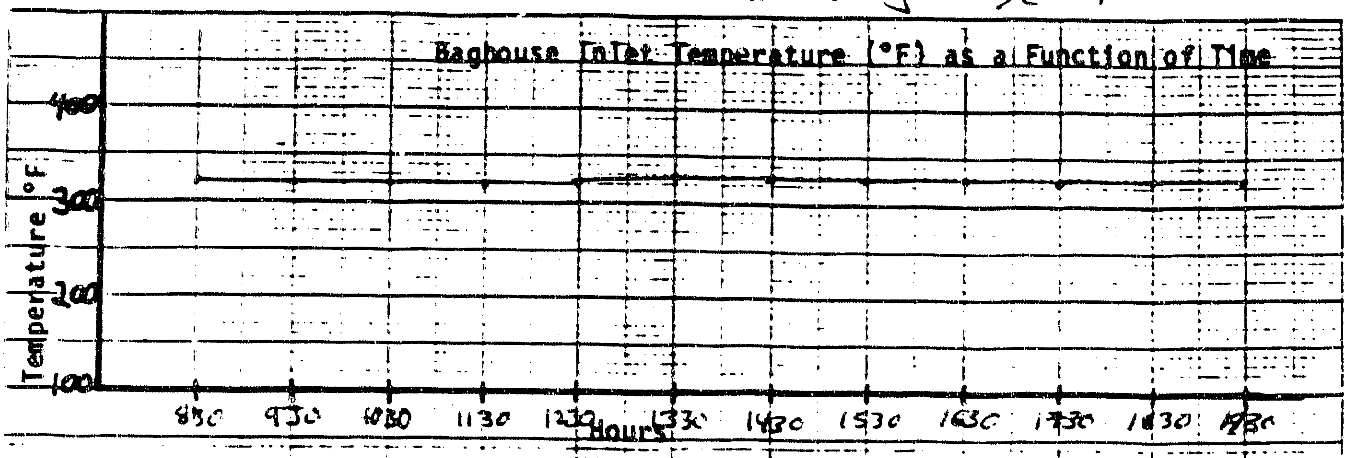
Inlet MMD ____ μm CMD ____ Tefaire outlet MMD 6.4 μm CMD 2.96 Ryton outlet MMD 7.0 μm CMD 2.99

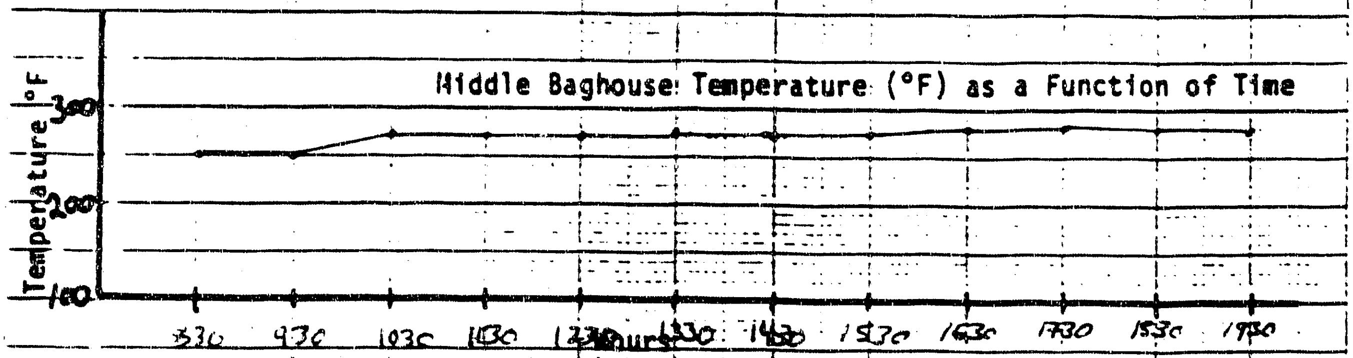
Particle Charge

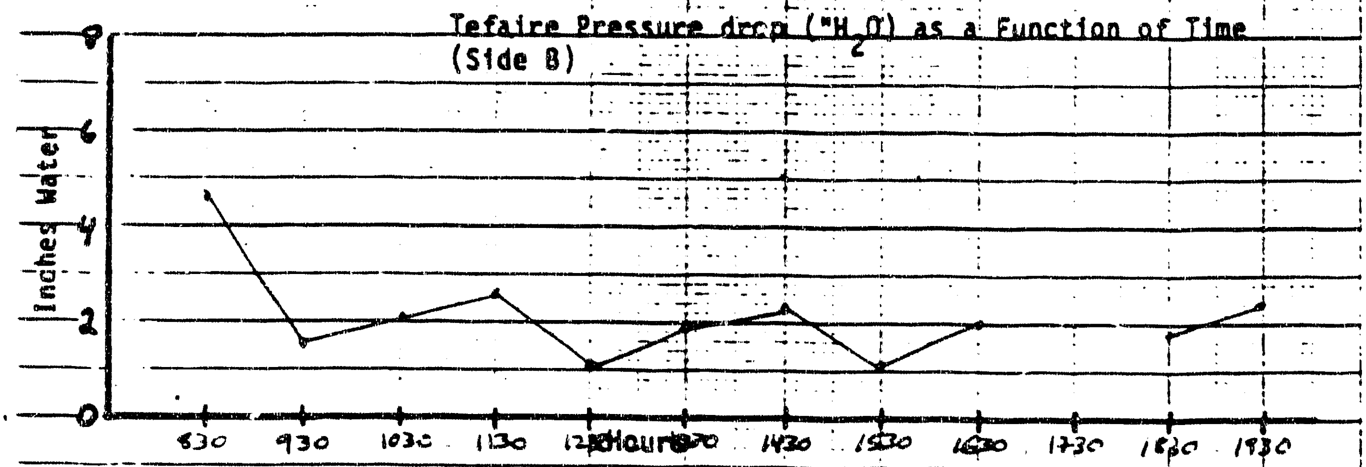
Charge to mass ratio (q/m) = .60 μC/gram

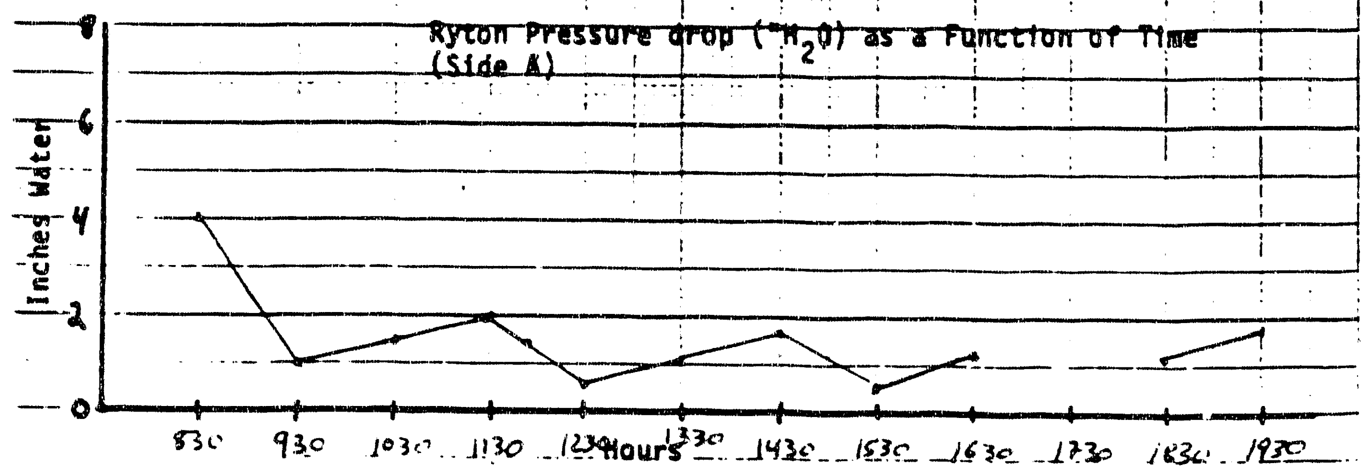
Charge to volume ratio (q/m^3) = .10 $\mu C/m^3$

No charge A/C = 4









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DE-AC22-89PC89807

Daily Summary

Date Aug. 31, 1990 Operator John Milojevac

Baghouse Inlet Temperature 317 °F

Orifice Flow Rate (Q_B) 175 Acfm (B) Tefaire

Orifice Flow Rate (Q_A) ______ Acfm (A) Ryton

Ash Type Eastern X Western ______

Corona Potential Base KV 20 Pulser KV 40

Pulse Rate 300 pps

Moisture Content 12.7 % (v/v)

Air to Cloth ratio ($Q/42.4$ ft^2) Tefaire 4.13 ft/min

Ryton ______ ft/min

Average Pressure Drop Tefaire 2.25 " H_2O

Ryton 1.625 " H_2O

Particle Concentration

Inlet 0.37 grains/dscf Tefaire outlet .00797 g/dscf Ryton outlet --- g/dscf

Particle Size Distribution

Inlet MMD 4.7 μm CMD 2.35

Tefaire outlet MMD 5.0 μm CMD 2.16

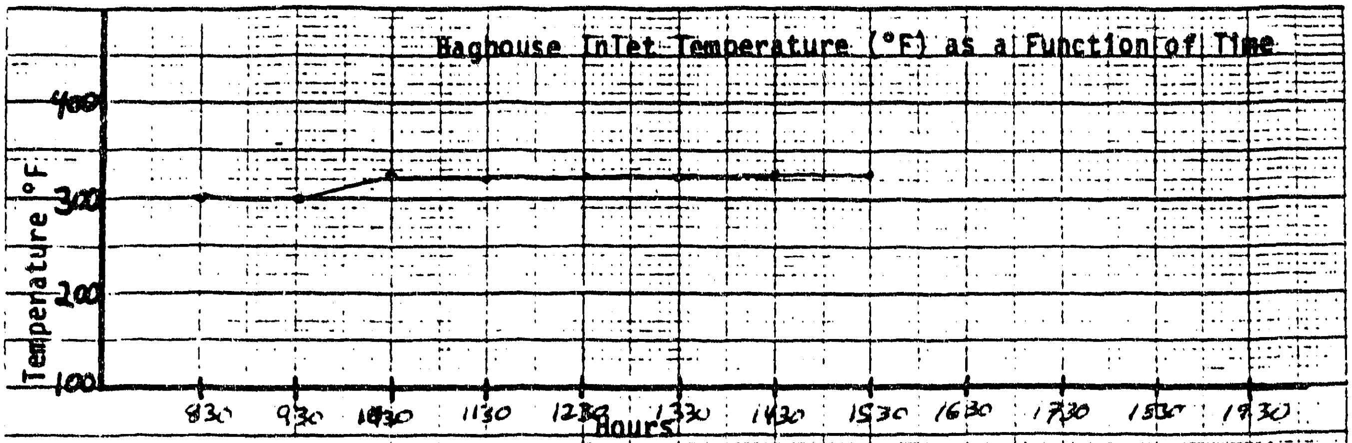
Ryton outlet MMD ______ μm CMD ______

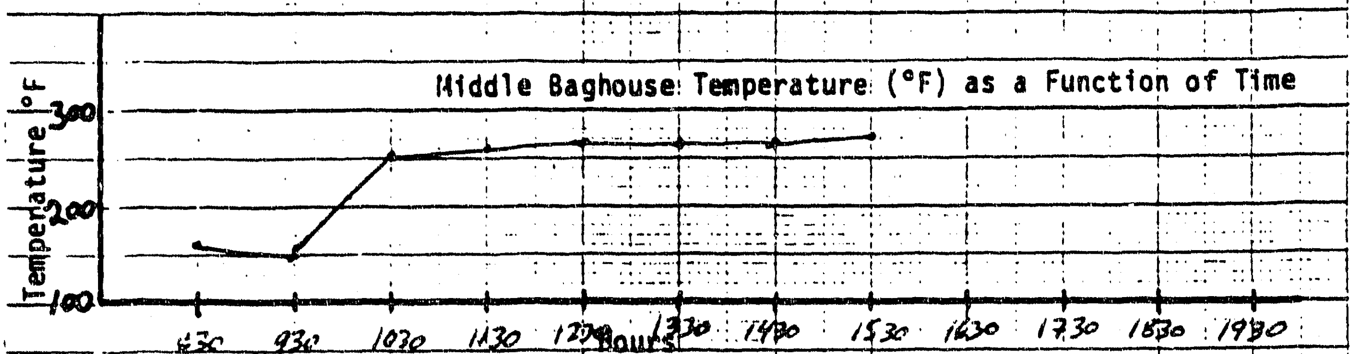
Particle Charge

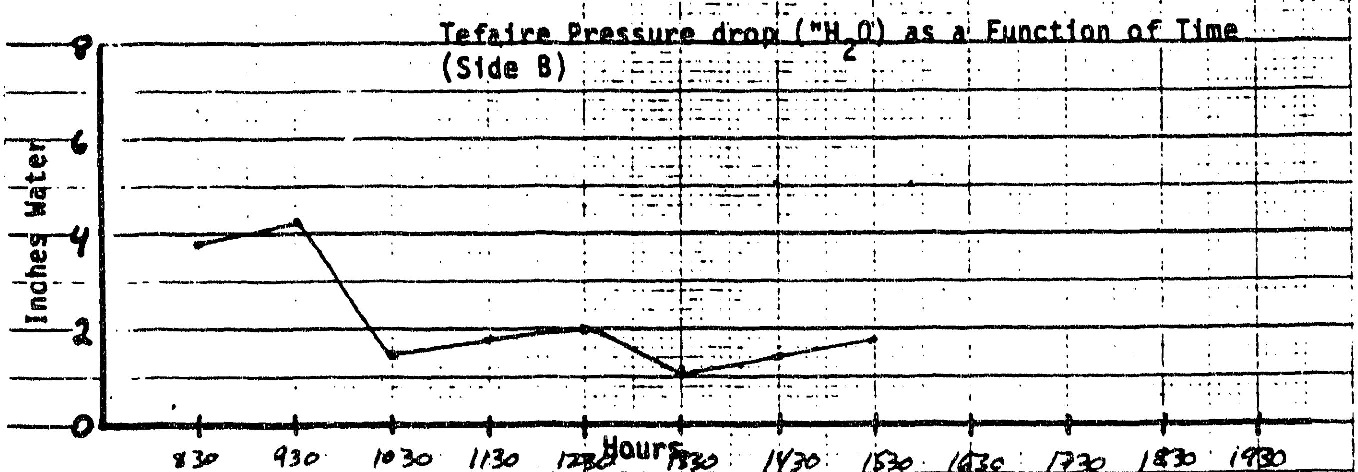
Charge to mass ratio (q/m) = 28.6 μC/gram

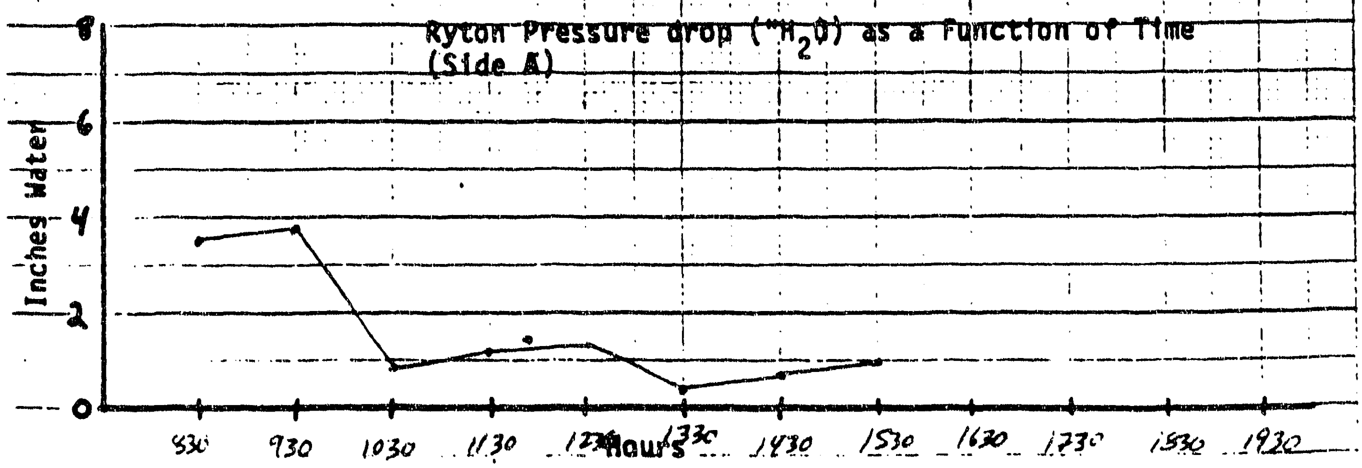
Charge to volume ratio (q/m^3) = 7.0 $\mu C/m^3$

MAX 40+20   A/C = 4









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